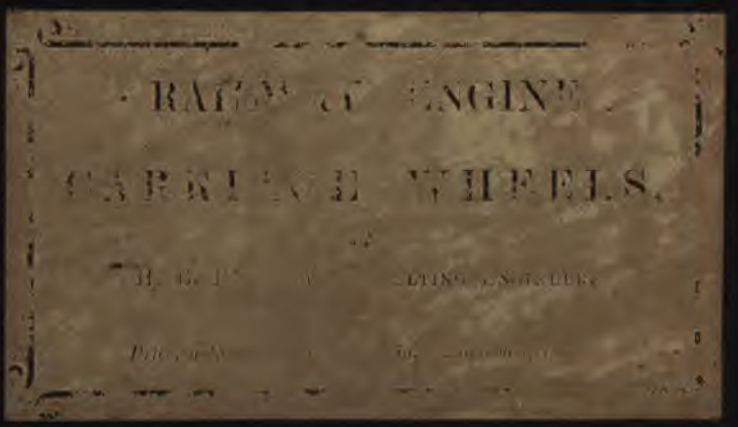

A

COMPARATIVE ACCOUNT

AND

DELINEATION

OF

RAILWAY ENGINE & CARRIAGE WHEELS,

COMPILED AND ARRANGED BY

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INTRODUCTION.

In submitting the following comparative account of Railway Wheels to the public, the author does not profess to enumerate all the Wheels that ever have been made—that would be almost impossible: he has, however, collected and arranged all those that have been published in the Repertory of Arts, the London Journal, and several other periodicals, in addition to many obtained from private sources.

The author thinks the accompanying engraving will be particularly acceptable to patentees, as it will enable them at a glance to form a pretty correct idea of what has been done in Railway Wheels; it also shews the necessity of searching diligently among previous patents before parties apply for fresh Letters Patent, as there are several instances in this list in which the same invention has been twice patented.

May, 1848.

OFFICE FOR PATENTS,

Exchange Arcade, Manchester.

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RAILWAY ENGINE AND CARRIAGE

WHEELS.

THE earliest patent for improvements in the construction of wheels to be used on railroads is that granted to George Hawks, of Gateshead, in the County of Durham, Iron Manufacturer, dated November 6th, 1807. The title of this patent is, "For a method of making, and likewise keeping in repair, cast iron wheels for coal waggons, and other carriages where such wheels are applicable." Figure 1 represents a front view and section of a wheel, constructed according to the patent of Mr. Hawks, who says in his specification, that "the usual method of making iron wheels for coal waggons, and other carriages where such wheels are applicable, is to cast their arms and rims in one entire piece, by which method they are partially weakened by the irregular contracting of the arms and rims in cooling, and are consequently subject to be frequently broken from trifling shocks or jerks; and when the rims are worn out or broken, or when any other part of the wheel is injured, the whole wheel becomes useless and must be replaced by an entire new one: these defects are removed by my invention, which consists simply in making or casting the wheel in two or more parts, and in joining those parts together by screws, rivets, pins, forelocks, keys, dovetails, rabbets, or mortises, as is frequently done with wheels used in the machinery of mills and similar purposes, or by any other convenient means; by this method the injuries occasioned by the contraction of the metal are avoided, the wheel is much stronger

with the same weight of metal, and in the end prodigiously less expensive than those cast in the common way of one piece, for, when partially injured by wear or accident, they can be repaired with little expense, whilst those on the old plan must be replaced by new ones on every accident."

On the 28th November, 1812, Thomas Rogers, of Dublin, obtained a patent "for a method of constructing wheels of all sorts of carriages." Mr. Rogers makes the naves of his wheels of cast iron, or such other cast metal or metallic compounds as is or are commonly known to be applicable to that or the like use or purpose; he makes the spokes of malleable iron, and the rim either of malleable iron united together with cast iron, or otherwise of good cast iron alone; he makes the spokes of the shape and form commonly used, or of any other shape or form, and recommends the ends to be jagged, so as firmly to become confined and fixed in the nave when cast. There is no drawing to this specification, nor is it mentioned whether the wheels so constructed are intended for carriages to be used on common roads or railways.

On the 30th September, 1816, a patent was granted to Wm. Losh, of Newcastle-upon-Tyne, and Geo. Stephenson, of Killingworth, "for a method or methods of facilitating the conveyance of carriages, and all manner of goods and materials, along railways and tramways, by certain inventions and improvements in the construction of the machine, carriages, carriage-wheels, railways, and tramways employed for that purpose." Fig. 2 represents a front view and section, and Fig. 3 similar views of another wheel described in the above patent. In Fig. 2, the arms are made of wrought iron cast into the nave, and dropped into the mortise holes in the rim, which are dovetailed, to suit the dovetailed ends of the arms. The arms are heated red hot previous to dropping them into the holes, in order to cause them to extend sufficiently for that purpose, for when cold they are too short. The arms, when cooling, are drawn with a sufficient force to produce a

degree of combination between their dovetailed ends and the mortises of the rim, they are afterwards keyed up. In Fig. 3, the wheel is of cast iron, with a malleable iron tire. This wheel is made with curved spokes, as seen in the drawing, and with a slit or aperture in the rim, into which a key is inserted. The reason of this is, that on the application of the hot tire the cast metal expands unequally, and the rim is liable to be cracked, and the arms drawn off, unless the first is previously slit or opened, and the latter curved, which allows them to accommodate themselves to the increased diameter of the wheel; by this formation of the wheel the tire might be forced on when cold, and keyed up afterwards. In the same specification is also shewn a rolley, or tram wheel, with a plate of malleable iron to form the junction between the nave and the cast metal rim.

Mr. R. W. Brandling, of Low Gosforth, obtained a patent, on the 12th of April, 1825, "for certain improvements in the construction of railroads, and in the construction of carriages to be employed thereon and elsewhere." In the specification, Mr. Brandling proposes to construct the rims or tires of wheels so that they can be used either on railroads or common roads,—one mode of doing which is by forming a projection on each side of the face of the rim, and, consequently, a hollow in the middle, which latter is intended to run on the railroad, while the projecting rims serve only as guides; but on a common road these latter on the contrary, sustain the burden, while the hollow part remains unemployed. In another construction of wheels described, one half of the rim rises an inch or inch-and-half above the other half on the surface, and, when used on a railroad, the former serves as a guide or flanch to prevent the wheel from rolling off, but when on a common road, alone sustains the carriage.

Fig. 4 represents a front view and section of a wheel, patented on the 11th October, 1826, by Mr. Theodore Jones, of London. The rim of this wheel is of the best malleable iron, rolled into the form shewn in the section. The spokes are conical at the head,

to give them a firm bearing from the outer edge of the rim, and are tapped at the other end to receive nuts, by which they are drawn up tight, and the nave suspended in the centre of the wheel. Split keys pass through a slit in the spokes, and through a hole in the nuts, to prevent them from turning, and thereby loosening the spokes.

On the 28th May, 1829, Mr. Ross Winans, of Vernon, in the County of Sussex, North America, obtained a patent "for certain improvements in diminishing friction in wheeled carriages, to be used on railroads and other roads, and which improvements are applicable to other purposes." The first of these objects is intended to be effected by substituting, in place of fixed bearings for the axles, anti-friction wheels, in which the ends of the axles run. In reference to the second part of the invention, it is proposed that the periphery of the running wheels should be made conical, in order that, on such parts of the line of railway as may be curved, the larger diameter of the wheel on one side may run upon the more extended line of the curve, whilst the smaller diameter of the opposite wheel may pass along the shorter line, or lesser curve.

On the 31st August, 1830, a patent was granted to W. Losh, of Benton House, Northumberland, "for certain improvements in the construction of wheels for carriages to be used on railways," the object of which is to render such wheels more durable, and less liable to be damaged or broken, than those wheels hitherto in use upon railroads. Fig. 5 represents a front view of a wheel, with a cast iron nave, and Fig. 6 is a sectional elevation of the same. Fig. 7 is another section of a similar wheel, the spokes of which are made by bending a bar of iron into the shape shewn in the drawing. The central nave is of cast iron, and the wrought iron spokes are provided with elbow bends, near the middles of their lengths, the prolongations beyond those elbows being curved so that, when the proper number of such spokes are put together, their curved prolongations beyond the elbow bends form a complete circle, and the straight parts within those elbow bends form

the radii of that circle. The cast iron forming the nave is run around the inner ends of all the spokes, which had previously been indented, to prevent them drawing out of the nave. For security against splitting the cast iron nave, circular hoops of malleable iron may be shrunk on the projecting ends of the nave, as seen in the drawing. The outer ends of the curved prolongations of the spokes forming the circular rim overlap each other sufficiently to enable them to be united one to another by welding, or by rivets, and the outer rim or tire, that runs upon the rails, is fixed upon these curved prolongations by the means usually employed for applying the hoop tire on wheels for carriages. Fig. 8 represents a front elevation and section of another modification of Mr. Losh's improvements; in this instance, the spokes are each formed of two bars of iron, the prolongations of each single bar being bent in opposite directions, form a curved prolongation of the compound spoke on each side, and where those ends overlap they may be rivetted together, or welded, or the bar of which each spoke is formed may be made with two elbow bends, the middle part between those two elbow bends forming a portion of the circular rim; a proper number of sectors thus formed being put together with the straight parts in contact, will form a wheel, ready to be provided with a boss and surrounded with a tire, in the manner already explained.

John Hanson, of Huddersfield, obtained a patent, on the 31st Aug., 1830, "for certain improvements on locomotive carriages." The object of this invention is to enable the wheels of railway carriages to turn out of their straight course without shifting the positions of their axles, and the inventor proposes to obtain this object by making the end of the axle spherical, and this spherical end of the axle is confined in the centre of the nave of the wheel by two flanges, one of which is made with a conical hole, to admit the end of the axle.

In November, 1830, Mr. Wm. Frost, of Derby, sent a model of a railway wheel, similar to that shewn in elevation and section

at Fig. 9, to Mr. Wm. Fairbairn, of Manchester, to be submitted to the directors of the Liverpool and Manchester Railway. Mr. Frost proposed to have a cast iron wheel, having a groove going round the face of it, the bottom of which was to be provided with a layer of leather or flannel. The blocks of wood which form the tire were placed so that the grain of the wood was set endways towards the rails, and Mr. Frost thought that good beech would be the most proper for the purpose. The advantages expected to be obtained by the use of these wheels, are superior comfort to the passengers, and less wear and tear in the railway carriages.

In the *Mechanics' Magazine*, of May 7th, 1831, vol. 15, there is a letter from Sir George Cayley, dated Brompton, County of York, Dec. 5th, 1830, and a sketch of a wheel to be used on railways, with the following description.—"If the wear and tear of railway conveyance be found too expensive, owing to the friction caused by such high pressure and great velocity, and that the use of springs to these carriages are not sufficient to remedy this evil, I think it probable that a dovetailed groove, filled with hard oak, driven in in small pieces endwise, within the rim of the wheels, and then turned in a lathe till circular, might be serviceable, and could be cheaply renewed; these pieces might be secured in their bed by a fox wedge, as commonly practised in similar cases."

On the 30th April, 1831, Mr. George Stephenson, of Liverpool, obtained a patent for "an improved mode of making wheels for railway carriages." Fig. 10 represents a front elevation and section of a railway wheel, having eight oval tubular arms, which are enlarged a little at each end, and are prepared with borax for casting the cast iron nave and rim around the ends of them. The hollows of the said tubular spokes should be filled up with sand, except at so much of the ends thereof as are intended to have the cast iron run into the said hollows. Fig. 11 represents a front elevation and section of another modification of this invention. The arms or spokes, which are twelve in number, are cylindrical tubes of wrought iron, instead of tapering flattened tubes, and

they are not situated in a plane, but one-half of the number are dished towards one side of the wheel, and the intermediate six spokes are dished towards the other side of the wheel, to give greater lateral strength thereto. It will be necessary to insert three cores across the cavity of the mould, which is left by casting the circular rim of the wheel, whereby the said rim when cast, will be formed in three distinct segments, with small intervals between the ends of them, in order to allow for the contraction of the cast iron which must take place in cooling from a liquid state till it becomes cold.

Mr. George Forrester, of Liverpool, obtained a patent on the 5th. Sept. 1831, for "certain improvements in wheels for carriages and machinery, which improvements are applicable to other purposes." The invention specified under the above patent, consists in a peculiar method of combining cast iron with wrought or malleable iron, in the construction of wheels of all descriptions for carriages or machinery, where the invention may be found practible. Fig. 12 represents a front elevation and section of Mr. Forrester's wheel, which is constructed of a light or skeleton frame, of wrought iron or steel, formed to the same shape, but of less dimensions than the wheel required; this skeleton frame is made bright, and free from oxide, by being cleaned in any convenient manner, as grinding, scouring, or filing, so as to adapt it to receive a coating of lead or bismuth, or of tin, or zinc, or any mixture of those metals, such coating being given to it by similar means to those used in the process of tinning metals. The article to be cast having been moulded from the pattern, in sand or loam, in the usual way, the skeleton frame, as above stated, is carefully laid in the middle of the respective parts of the mould, projecting pieces being attached to the skeleton frame to keep it in its proper place; the mould is then to be closed, and the cavities formed by the pattern are to be filled up with fluid iron as in common casting, when the operation is completed. It is necessary to make a number of holes through the circumference of the wrought iron skeleton rim for the purpose of allowing the fluid iron to flow

through the holes and fix itself solidly all around the skeleton wheel.

Mr. Richard Roberts, of Manchester, obtained a patent on the 13th. April, 1832, for "a certain improvement or certain improvements in steam engines, and also in the mechanism through which the elastic force of steam is made to give impulse to, and to regulate, the speed of locomotive carriages." Fig. 13 represents a wheel constructed according to Mr. Robert's specification: the nave is of cast iron, and has a rabbet at each end to receive wrought iron hoops, the rabbets are a little taper towards the middle of the nave to hold the hoops in their places. In the direction of the axis of the nave there are grooves for the reception of the inner end of the spokes which are of wrought iron and are fitted accurately into the above mentioned grooves in the nave, the shouldered portions of them filling those parts of the grooves which are within the cylindrical surfaces of the rabbets; the spokes are firmly held in the nave by the hoops let on hot over the rabbets of the nave and the T ends of the spokes. The outer ends of the spokes are spread on both sides in the direction of the circumference of the wheel, and are rivetted to the inner ring or felloe. The tire is put on and secured to the felloe in the usual way. The object of constructing wheels in the above mentioned manner was to obviate the difficulty previously experienced in casting the nave on to the spokes.

Fig. 14 represents a wheel of which there is a drawing in the Mechanics' Magazine, of December 8th., 1832, vol. 18, page 149. The inventor of this wheel signs himself Junius Redivivus, and proposes the application of such wheels to steam carriages for common roads. The wheel is constructed of a fixed centre piece, keyed on the axle of the carriage, and provided with eight hollows to admit eight circular springs, which are recessed into eight similar hollows in the outer rim or tire of the wheels. By this arrangement of parts it will be seen that the weight of the carriage is always supported by four or five of the circular

springs, forming part of the wheels, and the springs hitherto used and placed between the axles and the body of the carriage may be dispensed with. The above described wheel is very similar to the one patented in 1835, by Mr. Adams.

On the 28th Oct. 1833, Mr. David Redmund, of London, took out a patent for " certain improvements in steam carriages, which improvements are applicable to other purposes." Fig. 15 represents, a front view and section of a wheel formed of malleable cast iron, and the castings are exposed to a bright red or annealing heat for eighty-four hours. Where great strength is required, the spokes should be cylindrical tubes, perfectly straight, but where strength is not so much an object, they are formed as shown in the drawing, by which form a slight degree of elasticity is obtained, to obviate the concussions arising from rough roads, &c. The nave of the wheel is made with a loose flange, which holds the spokes in the recesses made in the nave to receive them, and the outer extremities of the spokes rest upon bosses cast to the segments forming the felloes. The drawing represents a wrought iron wearing tire shrunk on the felloes; but Mr. Redmund also proposes to have an inner tire shrunk on the felloes, and the outer or wearing tire cast in segments and held by screws to the inner tire and felloes. A space is left between each of the segments forming the outer tire in order to allow for the expansion of the metal by wear.

Mr. Benjamin Hick, of Bolton, took out a patent, dated 8th. Oct., 1834, for " certain improvements in locomotive steam carriages, parts of which improvements are applicable to ordinary carriages employed for other uses." Fig. 16 represents a wheel in front view and section, the tire of which is of wrought iron, and case hardened; the nave is of cast iron, and is connected to the tire by means of two discs of sheet iron rivetted to the nave and to the internal flange projecting from the tire, as clearly seen in the drawing. These wheels possess a greater degree of strength, with the same quantity of material, than any hitherto made, and the

liability of the tire getting loose is entirely obviated, as the side plates are rivetted to the internal flange of the tire itself.

Mr. R. Whiteside, of Air, obtained a patent, on the 20th Nov., 1834, for "certain improvements in wheels of steam carriages, and in machinery for propelling the same." This invention is seen in Fig. 17, which represents a wheel for a steam carriage. The spokes are rivetted, or otherwise fastened, to the tire at one end, and at the other secured to a flat ring, the central space of which varies according to the play intended to be allowed to the springs. A quadrangular iron framing is fastened to the rim of the wheel, to which is suspended a plate of iron, having a hole in its centre to allow the axle box to pass through. The four spiral springs seen in the drawing are attached to the inside of the rim, and to the nave of the wheel. The inventor remarks that springs have before been placed in or adapted to wheels, and therefore, he does not claim them, but confines his claim, so far as relates to the improvements on wheels for steam carriages, to the application of the two quadrangular frames for preventing the strain of the power applied to propel the same coming on to the springs.

On the 13th, March, 1835, a patent was granted to William Bridges Adams, of London, for "an improved construction of wheels for all kinds of carriages in which springs are commonly used." Fig. 18 represents a front view and section of a wheel constructed according to Mr. Adams's patent, and it will be found, on comparison, to be very similar to the wheel shewn in Fig. 14, and described in the Mechanics' Magazine of 1832. In Fig. 18, the felloe or rim of the wheel is made of any required number of curved pieces of wood, accurately fitted together as the staves of a barrel; these are placed round a ring of steel, as an inner tire, and are bound tight on the outer periphery by the ordinary tire, or ring of iron, placed on to the felloe in a heated state, and shrunk thereon to keep the whole tight. To the inner part of this wheel four steel hoops are attached to bolts, at equal distances apart, and the opposite parts of these hoops are made fast to the central

box or nave, formed of iron plates, in the shape of a Maltese cross, and filled up with wood. A wheel so constructed will possess sufficient elasticity to give way to any small obstruction on the road that it may pass over.

There was a patent granted to Mr, John Ingledew, of Brighton, on the 14th April, 1835, for "an improved metallic safety wheel and revolving axle. "This invention is a peculiar mode of manufacturing iron wheels for railway carriages, but the author has not been able to find any drawing of the method of constructing them. The wheels are constructed with spokes, which are shouldered up into a central ring forming the nave, and are secured therein by transverse keys, and covered on their faces by flat disc plates. The outer ends of the spokes are made with crutched heads, secured into the iron felloe by dovetails and wedges.

Mr. John Day, of Peckham, obtained a patent, on the 14th of August, 1835, for "an improved wheel for carriages of different descriptions." The wheel described as the subject of this Patent is principally designed for railways. It is made entirely of wrought iron, by welding together bars of suitable dimentions. Two bars of iron, cut to the required length, are bent at their ends in the manner shewn in Fig. 20; a diamond shaped piece is then introduced between the bends, and the whole firmly welded together in a mould; the top parts of the bars are then bent back, as seen at Fig. 21, which shows one spoke of the wheel and a portion of the felloe. As many of these portions as are intended to constitute the wheel are then put together, as shewn at Fig. 19, with a small triangular piece to fill up the space left by the bending of the bars forming the spokes, and the scalf joints of the felloes being welded, the wheel is formed; an outer rim or tire may then be put on, and the nave of the wheel is brought to the required depth by welding discs over the spade shaped joints of the spokes.

A patent was granted to William Mason, of Camden Town, on the 24th Sept. 1835, for his invention of "certain improvements on wheels, boxes, and axletrees of carriages, for carrying persons and goods on common roads and railways." These wheels are proposed to be formed by combining a series of segmental pieces of wrought or rolled iron in the form of a circle which is to constitute the felloe. The segments are to be grooved round the periphery, and that groove filled up with wood, which will give lightness and strength. The several segment pieces are made with rebated ends, so as to overlap each other at the junctions, and the whole wheel is to be held firmly together by a ring of iron, constituting the tire, which being fitted on whilst hot will shrink, and confine all the joints securely. The spokes are of a cylindrical form, with shoulders, their ends being inserted into mortise holes in the nave and in the felloe.

Mr. Ramsey Richard Reinagle, of London, obtained a patent on the 6th of Aug. 1836, for "improvements in the construction of carriages for the conveyance of persons and goods or merchandise." Fig. 22, represents a front elevation and section of what Mr. Reinagle calls his inflexible or incompressible wheel, it is formed of wrought iron bars of suitable thickness, bent over a form the shape of an egg, the two ends being either welded or rivetted together to form a leg for insertion in the nave. The convex sides of these spokes are brought into contact with each other all round the wheel, and are rivetted two and two. The tops of the spokes are bolted to wide and deep wooden felloes; these may be sheathed with strong plates of iron, and the tire is extra thick and fluted. When the wheel is required to be elastic and anti-concussive, the bars of iron forming the spokes are bent in the shape of an ellipse, and the sides of the spokes do not come in contact, as in the wheel above described.

Mr. Henry Van Wart, of Birmingham, and Mr. Samuel Aspinall Goddard, of the same place, obtained a patent on the 22nd

Sept. 1836, for "certain improvements in locomotive steam engines and carriages, parts of which improvements are applicable to ordinary steam engines and other purposes, being a communication." Fig. 23, represents a wheel shewn in the specification of the above patent constructed partly upon the plan of Mr. Benjamin Hicks's patent disc wheels, but improved (according to the specification) in the facility of construction as well as in strength and lightness. The whole wheel is of wrought iron; slender spokes are dovetailed into the nave and their outer ends butt against the ring forming the felloe. The spokes are boxed on each side by a circular plate or disc of sheet iron, confined in their places by a series of tenons formed on the edges of the spokes, being passed through corresponding mortises in the discs and afterwards rivetted on the outside. The tire is put on hot and binds all the parts of the wheel securely together.

Fig. 24, represents a front elevation and section of a wheel patented in America, by Arundius Tiers, of Pennsylvania, the drawing is taken from the Franklin Journal of July, 1836. The body of the wheel is of cast-iron, and the projecting flanch for holding the wheel on the rail is chilled and hardened in the mould as it is cast; a small rim is formed on the opposite face of the wheel, and is intended to confine the wrought iron band, which is afterwards to be put around the wheel. The wrought iron band is first welded together in the form of a hoop, and then heated until it has expanded sufficiently to pass over the small rim above referred to, when it is allowed to become cool, and to contract upon the wheel as seen in the drawing. This wheel possesses all the advantages of a chilled cast-iron flanch with a wrought-iron tire, and is very similar to the one shewn in Fig. 3, and patented by Messrs. Losh and Stephenson, in 1816.

Sir George Cayley, of Brompton, County of York, obtained a patent on the 25th of April, 1837, "For certain improvements in the apparatus for propelling carriages on common roads or railways, part of which improvements may be applied to other

useful purposes." Fig. 25, represents a front elevation and side view partly in section of a wheel constructed according to this patent, being an improvement upon the wheel proposed by Sir George Cayley, in his letter to the Mechanics' Magazine referred to at page 14. In Sir G. Cayley's wheel the nave and spokes may be made according to any of the plans in use, but the rim must be formed as seen in the section having the flange cast with it, a loose ring is secured to the rim by several screws, and the recess formed by the flange and the loose ring is filled up with horn, tough wood, or other partially elastic substance.

On the 10th of May, 1837, a patent was granted to Mr. John Hague, of London, for "certain improvements on wheels for carriages." Fig. 26, represents a front and side view of a wheel, the spokes of which are formed by means of flat bars of iron, which are either shut or welded together at the point furthest from the centre of the wheel, or otherwise a bar of iron of the length of two spokes may be bended over and forged into a tenon, as shewn in the drawing, the other ends of the spokes are bent in towards each other in such manner, that when the number of which such wheel is to be composed are placed together, they will lie surface to surface, and in that form will have the cast-iron nave run on, in the ordinary manner. In putting the parts of this wheel together the tenons of the spokes are first placed in mortises or holes, formed in the ring or felloe which Mr. Hague prefers of wrought iron; the tire or outer rim is then shrunk on, and the wheel is completed. Fig. 27, represents an elevation and section of another part of Mr. Hagues' invention; in this instance he proposes to make use of two plates of wrought iron to connect the nave and the inner ring or felloe of the wheel; the nave would be cast on to the plates, and the ring or felloe would be rivetted to the plates as seen in the drawing. Mr. Hague claims the coating of the spokes or plates above mentioned with copper or brass in order, when the nave is cast thereon, the same may be more securely combined with the spokes or plates.

On the 13th May, 1837, a patent was granted to Mr. Pierret Barthelemy, Guinibert, de Bac of Brixton, "for improvements, applicable to Railroads." The improved wheel mentioned in this specification, consists of an axle-tree on which is fixed a ring, outwardly polygonal. It receives the centre part of the boss which is lined with wood. The spokes, alternately of different shapes and formed of wrought iron over wood, are placed into the recesses of the nave, on each side of which are placed two cheeks held by bolts on springs. The other extremities of the spokes are kept in their position by two outward rings or felloes fastened tightly together by bolts. They also seize hold of another ring which is to receive the tire of the wheel: felt is placed between these rings and to the extremities of the spokes. To retain the wheels on the rails a wrought iron ring is placed and fixed so as to have each extremity of its spokes to rest on the springs before-mentioned, the crease thus formed acquiring a desired degree of elasticity.

Mr. George Cottam, of London, obtained a patent on the 5th December, 1837, for "improvements in the construction of wheels for railway and other carriages." Fig. 28 is a wheel constructed on the principle proposed by Mr. Cottam, the most important feature consisting in a mode of affixing the iron spokes of the wheels to their rims or felloes by means of welding their ends to a flange formed on the inner circle of the felloe. The spokes are cast into the nave in the usual manner, and are placed in an angular position as shewn in the section, the contracted ends of the two spokes being forked, are to be brought into contact with the inner flange of the rim and there welded firmly together on to the ring or flange by any convenient means. The patentee says that for railway wheels, the felloe or rim may have its tire heated and shrunk on as is usually done.

On the 21st Feb., 1838, Mr. Jeremiah Grime, of Bury, County of Lancaster, obtained a patent for "certain improvements in manufacturing wheels, which are applicable to locomotive engines,

tenders and carriages, and to running wheels for other useful purposes; also in the apparatus for constructing the same." The nature of the invention is in the particular arrangement of such parts as are necessary to form the wheel entirely of wrought iron, and afterwards the whole is to be compressed and welded into a solid wheel. The necessity of a separate tyre-iron is thus dispensed with, and consequently, the outer rim or periphery of the wheel is more durable than when a separate tyre-iron is shrunk on in the usual manner. Fig. 29 represents a front elevation and section of a wheel constructed of a number of plates of sheet iron, perforated by a suitable machine so as to leave only the necessary metal for the outer rim, the spokes, and the nave; the inventor places as many of these plates side by side as will be required to constitute the requisite thickness ef the wheel, taking care to have the outer plates a little thicker than the rest and of as much larger diameter as will be requisite to allow for the formation of the flange upon its periphery. A few more circular pieces are also to be punched out of sheet iron and placed in the proper situations to form the projecting boss upon each side of the wheel. When the plates are all put together, a piece of metal tubing is passed into the holes punched at the extremity of each spoke, which serves to keep the pile of plates in one position during the process of welding, which is done in a furnace of a peculiar construction. After the wheel has been partially rammed or "puddled" in the furnace, it is placed in a mould and subjected to the pressure of a heavy weight, it is then ready to be put in the lathe and turned. Fig. 30 represents two views of a wheel constructed of bars of iron which must be rolled either with plain flat surfaces or with indentations; these bars are to be divided and cut into short sections or lengths, of the same size as the intended thickness of the rim or flange of the wheel. The required number of spokes or arms must also be prepared as seen in Figs. 31 and 32. The forged arms must be now all put together and the nave thus completely formed, the small pieces or segments are all to be placed or dovetailed together in the required order to form the outer rim or felloe of the wheel, and then the whole is put

into the furnace and treated in the manner described with reference to Fig. 29. An ordinary tire-iron may be welded on to the felloe, to save turning the metal from the solid. Fig. 33, represents two views of another wheel invented by Mr. Grime. In these figures it will be seen that the felloe of the wheel is made of solid bar iron, having the flange formed upon its periphery, and being connected with the nave by a pair of helically coiled springs, one end of each being welded fast to the felloe, and the other end to the nave. It is presumed that a wheel constructed in this manner, having springs of this peculiar form substituted in the place of spokes or arms, will lessen the shock upon the carriage as it passes over any irregularities of the road, and as such springs are capable of horizontal action as well as vertical, the motion of the train in running would be hardly perceptible.

Messrs. John Frederic Bourne and John Bartley, both of Manchester, obtained a patent, dated Sept. 6, 1838, for "certain improvements in the construction of wheels to be used upon railways and other roads, and which improvements are applicable to the construction of wheels in general." Figs. 34, 35 and 36 represent different parts of a wheel, and fig. 37 represents, in front view and section, the said parts when put together, forming a complete wheel of wrought iron. The patentees propose, first to make the nave of the wheel by taking two straight pieces of bar iron of about three inches square, and when heated they are bent into a ring of the size of the intended nave. The arms are made of flat iron, about three inches by one and a quarter inches, cut into lengths of rather more than half the length of the arms or spokes, a head is formed on each of them, and, in this instance, five such arms are welded to each of the rings or semi-naves, as seen in fig. 36. The remaining pieces or semi-arms are next to be welded to ten pieces of flat bar-iron, say five inches by one and a quarter inches, forming segments of the felloe as seen in fiig. 35. Five of the pieces of the felloe with their semi-arms are then welded to the five semi-arms welded to the naves, thereby forming half of the wheel, as seen in fig. 34; all the arms or spokes being

set one way as seen in the section. Two of the half wheels thus made are placed face to face in such manner that the spaces between the arms or spokes exactly intersect each other, thereby presenting an entire wheel as seen in fig. 37, the section of which shows the set of the arms in opposite directions in order that the wheel may resist any lateral pressure. Small angular pieces are then cut out of the points of contact of the segments forming the felloe, and corresponding V. pieces are to be welded in their places. The wheel, in the state above described, is ready for being turned, after which an ordinary tire is shrunk or rivetted on in the usual manner. Messrs. Bourne and Bartley propose making wrought-iron wheels with cast-iron naves of the following construction. Take a straight bar of the requisite dimensions for the rim of the wheel and of the same length as its circumference, holes are then to be punched through the bar corresponding with the number of spokes required, and the holes countersunk, round spokes are rivetted into the said holes and set in opposite directions as before described; the bar forming the rim is bent into a circle and welded, and a cast-iron nave is cast in the centre, embracing and fastening all the other ends of the arms; the wheel may be completed by putting on a tire in the usual manner.

Fig. 38. represents a railway carriage wheel, proposed by Mr. John Rivington, jun., of Sydenham, in a letter to the editor of the Mechanics' Magazine, dated the 26th March, 1839. Mr. Sydenham's plan is the same, in principle, as that proposed in 1830 by Mr. Frost, and described with reference to Fig. 9, the only difference being that Mr. Sydenham secures his blocks of wood forming the tread of the wheel by small diagonal bolts as seen in the drawing.

On the 9th of April, 1839, Mr. Thomas Parkin, of London, obtained a patent for "improvements in railroad and other carriages, and in roads and ways on which they are to travel." Fig. 39 is a front and side view of a railway-wheel, constructed of wooden sectors, secured by bolts and nuts to the back plate of

cast iron, which also forms the flange. The wooden sectors are to be well boiled, and the joints crossed, so as to secure rotundity. Mr. Parkin proposes to cast pulleys on the naves of the engine wheels, and to have a band passing from the nave of the driving-wheel to each of the other wheels, in order to relieve the driving-wheel of part of the stress thrown on it in giving motion to the train.

Mr. J. Coope Haddan, of Waterloo-road, Surrey, and Mr. George Hawkes, of Gateshead, obtained a patent on the 17th Oct. 1839, for "certrin improvements in the construction of wheels for carriages to be used on railways." Fig. 40 represents a wheel constructed according to this patent; each spoke is made of a wrought iron bar, having four obtuse bends, eight of these bended bars are placed in a circle, and the nave is cast around their inner ends in the manner usually practised. The inner rim or hoop of wrought-iron is then heated, and placed upon the eight curved extremities of the spokes, to which it is secured by four rivets. The outer or flanged wrought-iron tire is also heated, and shrunk on, and when cold is rivetted through the remaining four spokes and the inner rim. Fig. 41 is a wheel of a different construction, with the spokes attached by means of heads or bends to an inner hoop or tire, having a groove or recess formed on the outside of the same. The spokes are made of wrought iron bars, which, when heated, are bent about two inches from one end, so as to form a one-sided head, which is curved in a mould, so as to fit into the inner rim; the spokes are also slightly bent, in the contrary direction, at the other end, where they enter the nave. The inner rim or felloe of wrought iron has a groove around it, to suit the size of the iron of which the spokes are made, and is provided with eight equidistant holes, equal in size to two of the bars laid together. Into each hole two of the bars are driven, so as to form a compound spoke, and they are held in contact while the nave is being cast around them. The outer tire is then put on, and rivetted in the ordinary manner. Fig. 42 represents a wheel, the spokes of which are formed by passing wrought iron

bars half way through holes in the tire, which may be of cast or wrought iron, having a rib inwardly, through which eight equidistant holes are made. The middle of a straight bar of wrought iron is heated nearly to a welding heat, and pushed half way through one of the holes in the rib, and instantly bent into the position shewn by dotted lines, and then struck on both ends, so as to "upset" or swell the heated part, which is within the hole in the rib, and in contact with the inside of the tire. The two ends of all the bars, when cold, are then drawn sufficiently close together, by curving, to allow the nave to be cast around them. Before the arms have had time to cool, and before the nave is cast on, they are twisted edgewise in opposite directions, so as to set them a little out of perpendicular with the nave, as seen in the drawing.

Fig. 43 represents a cast iron wheel, patented in America, by S. Truscott, G. Wolf, and J. Dougherty, of Pennsylvania. It is called the "Double plate car wheel," and is described in the *Franklin Journal* for January, 1839. The rim of the wheel is similar to those in ordinary use, but instead of arms, two parallel convex plates are substituted, cast with the nave and rim, as clearly seen in the drawing. The hollow between the plates is formed by a core in the process of casting, in the manner well known to iron founders.

Fig. 44 is a cast iron wheel, very much like the one above described, and also patented in America, by J. Bonney, C. Bush, and G. C. Lobdell, of Delaware. In this wheel, the convex plates, instead of being parallel, are placed facing each other, as seen in the section, and the boss or nave is cast in two separate parts, by which arrangement the shrinkage of the metal in cooling does not weaken the side plates, as is the case when the nave is of one piece throughout.

A patent was granted to Mr. Henry Dircks, of Liverpool, dated 12th May, 1840, for "certain improvements in the construction

of locomotive steam engines, and in wheels to be used on rail and other ways, part of which improvements are applicable to steam engines generally." Fig. 45 represents a front view and section of the improved wheel mentioned in this patent: the body of the wheel is of the ordinary construction, but the rim or tire is formed with a channel or groove around it, in which are fixed several segments of wood, having the wood placed radially, to form the running or outer periphery; these segments of wood may be fastened into the channel with bolts, as seen in the drawing, or by turning a groove half in the metal and half in the wood, and running metal therein. On referring to Figs. 9 and 38, it will be seen that Mr. Frost and Mr. Rivington had both proposed to construct wheels with the running surface of wood, before Mr. Dircks applied for his patent, and on referring to Fig. 25, it will be seen that Sir George Cayley introduced a similar wheel in his patent, dated April, 1837.

Mr. D. Gooch obtained a patent, dated May 28th, 1840, "for improvements in wheels and locomotive engines, to be used on railways. The nature of this invention consists in forming the outer or working surface of the tire of engine and carriage wheels of steel, which may be made of any required degree of hardness. Fig. 47 represents a faggot of wrought iron bars, these are hammered or rolled into a solid bar, and afterwards drawn in the rolls to the shape shewn in Fig. 48. An indentation is then made longitudinally in the bar, in order to prepare it for welding, as seen in Fig. 49. Fig. 50 is a section of a faggot of steel bars, piled so that when hammered into the wedge form, Fig. 51, their edges form the broad surface of the solid steel bar across the grain of the metal. The two bars of iron and steel are afterwards heated to a welding heat, and laid together in the position shewn in Fig. 52. They are then welded together, by the action of hammers or rollers, and drawn into the form shewn in Fig. 53. The compound bar is then made into a hoop or tire, and bored out and turned to the proper guage. The tire should be heated very regularly to a red heat, and put on the wheel, the whole is then

plunged into the water, or other frigerific mixture, to contract the tire on the wheel, and harden the steel, as seen in Fig. 46. The surface of the inside of the tire may also be a little curved, as seen in Fig. 54, and shrunk as before on the wheel; in this case, the rivets for holding the tire on to the wheel may be dispensed with.

On the 16th Dec., 1840, Mr. Joseph Beattie, of Lambeth, obtained a patent for "certain improvements in locomotive engines, carriages, chairs and wheels, for use upon railways, and in certain machinery to be used in the construction of such parts of such invention." Fig. 55 represents a wheel constructed according to Mr. Beattie's improvements and the mode of attaching the wheels to the axles by means of an elastic medium. The nave is of cast-iron, having upon its periphery a number of mortises, into which are tightly driven the segments of wood with the grain in the direction of the radii of the wheel; the inner end of these segments abut against the periphery of the nave and against pieces of wood placed in the bottom of the mortises. Wooden wedges are driven between the inner ends of the segments as seen by dotted lines in the front view. The inner tire with the flange on it, is now shrunk on the ends of the wooden segments, and is held in its place by the small flanges projecting from its inner circumference. The outer tire, which the patentee prefers making of steel, is now shrunk on the inner tire, which had previously been turned slightly conical, and the two tires will remain firmly united without the aid of pins or rivets. Between the joints of the segments, as also between them and the nave, are placed zig-zag springs of the form shewn separately; these, when placed between the joints in making the wheel, are bent flat and exert their elastic tendency to counteract any effects produced from concession.

A patent was granted to Mr. Edmund Taylor, of London, on the 11th May, 1841, "for improvements in the construction of carriages used on railroads." The patentee has shown several methods of constructing wheels, from among which the four fol-

lowing have been selected. Fig. 56 represents a front view and section of a wheel, with a portion of the axle which is forged with a swell to receive the ends of the wrought-iron spokes. The other ends of the spokes are screwed, and an oblong hole or slit is cut through the threaded part. The hexagon nuts on the spokes have holes drilled through each of their six sides, and are provided with washers curved on one side and flat on the other to give the nuts a true bearing: these washers bear against the three wrought-iron segments, forming the inner tire, and upon them are placed the six wooden segments shewn in the drawing, and turned true outside to receive the ordinary flanged tire. In putting this wheel together, first drive the spokes tight into the holes of the axle, screw on the nuts as far as they will go and put the washers above them, then place the three portions of the inner ring with their joints over alternate washers; around this hoop place the six wooden segments which are held together by wrought-iron dowels, and then place the outer tire (cold) over all; the nuts must now be tightened up and held fast by split keys which pass through the holes in the spokes. The tire should be bolted on in a few places to secure the whole. Segments of papier maché (one half the depth) may be substituted for the wooden segments. Fig. 57 represents a wheel very similar in its construction to that above described, the difference consisting in the nave, which is cast upon the ends of the spokes, and in the method of constructing the felloes, which consists of three concentric hoops of ash, or other wood, bent by steam; the tire is put on cold as above mentioned, and the nuts tightened up to complete the wheel. Fig. 58 represents a wheel, with seven spokes, formed of wrought-iron bars bended upon a shape or block of cast-iron; upon the inner ends of these spokes the nave is cast. Around the continuous rim formed by the middle portion of the bars of iron, six segments of wood are placed and fastened with dowels at the joints; over these fix a band of thin sheet iron. Around the wheel thus formed shrink on the tire by first heating it, and then place both wheel and tire in water to prevent the wood being injured by the heat. Papier maché may also be sub-

stituted for the wood, or the segments of wood may be baked and compressed about 20 per cent., and the tire applied cold. Fig. 59 represents a modification of the above described wheel, the seven spokes are made in the same way, but instead of forming a continuous rim, about three inches space is left between each of the spokes, a space of about one inch is also left between the bars at their insertion in the nave. In these spaces formed by the spokes not being in contact, wedges of wood are driven tight, and, on the heads of the wedges, projecting plates of sheet-iron are fastened. The tire is put on hot, and, in cooling, first contracts upon the projecting plates and forces the wedges still further, until the plates form a circle with the ends of the spokes. Wedges of papier maché may also be substituted for those of wood.

On the 26th June, 1841, Mr. William Losh, of Little Benton, Northumberland, obtained a patent for "improvements in the manufacture of railway wheels." The patentee considers that the metal wheels used on railways suffer great injury from the effects of the vibration arising from the concussions to which their tires are subjected, being communicated through the solid metal, whereof the wheels are constructed, to the felloe, spokes, and nave, by which vibrations the parts are frequently broken or disjointed. He purposes, therefore, to introduce, between the iron tire hoop and the felloe or rim of the wheel, a ring of wood, felt, or rope, or some other more elastic or non-conducting material, which, by intercepting the vibration of the tire, shall prevent the effects of concussion being communicated to the other parts of the wheel. Several constructions of iron wheels are exhibited in the drawing accompanying the specification, but not claimed, as being principally like those for which Mr. Losh has obtained a former patent in 1830, see Figs. 5, 6, and 7. They are merely represented for the purpose of shewing the manner of introducing the non-elastic or non-conducting material between the outer tire iron hoop and the felloe, or rim, and interior of the wheel. The same result is obtained by Mr. Taylor's patent above described, where the felloes are made of wood or papier maché.

On the 7th July, 1841, Mr. George Onions, of London, obtained a patent "for improved wheels and rails for railway purposes." The patentee describes his improvements as follows: "My process for improving wheels for railway purposes consists in casting such wheels of iron made from Cumberland or Lancashire ore, which are afterwards made malleable by annealing, and are subsequently casehardened." On referring to Mr. D. Redmund's improvements, patented in 1833, it will be seen that he proposes to anneal railway wheels formed of malleable cast iron.

A patent was granted to Mr. John Oliver York, of London, on the 21st December, 1841, "for improvements in railway axles and wheels." Fig. 60 represents a wheel constructed according to Mr. York's patent; the spokes, nave, and felloe may be made of cast or wrought-iron, and a groove must be formed in the inner rim to receive the three wooden segments, which, with the six curved wedges placed upon them, constitute the felloe of the wheel; a screw nut is let into the broad end of each of the curved wedges, and a double screw having a right hand thread at one end and a left hand thread at the other, each takes into the nuts in the above wedges; the double screws are turned round by means of the holes made in a shoulder provided for that purpose, and they are held in their places by pieces of metal fixed in the felloe. In putting the parts of this wheel together, the ring of wood is to be placed round the felloe, and then the tire, into which is turned a recess or groove, is to be placed thereon without being heated. The curved wedges are then caused to move from each other by the screws above mentioned, which will enlarge the diameter of the wood ring and thus securely hold the tire; the three screw bolts which pass through the tire, the wooden segments and the felloe, retain the parts from moving during the expanding of the wood ring. Fig. 61 represents another modification of this invention, in which the wood ring has inclined surfaces formed on its inner edges, as shewn in the section. Eight spokes formed at the outer ends so as partly to embrace the wood felloe, are cast, or otherwise fixed, to a semi-nave, and another

similar set of spokes being prepared, they are placed upon an axle, on which are formed screws provided with nuts. When the parts of this wheel are put together, the segments of wood are laid between the bent ends of the spokes, and the tire is placed upon them; the sets of spokes are then brought nearer to each other by screwing up the nuts on the axle, which thereby enlarges the diameter of the wood segments and causes them to fill up the groove made in the tire to receive them. The nuts on the axle are held from moving by screw bolts passing through the projecting plates of the nuts into the semi-naves, as seen in the section. Fig. 62 represents another wheel very much like the one just described, the side plates forming the body of the wheel are made with inclined flanges to receive the wood segments, and they are drawn together by bolts, as shewn in the drawing, instead of having screws on the axles, as in Fig. 61.

Fig. 63 represents a wheel, of which a drawing was sent to the *Glasgow Mechanics' Magazine*, by a Mr. Hossack, of Warrington, on the 17th February, 1842, who observes that a wheel may be constructed on this principle much lighter as to material than any in use. The support, which rests upon the centre of the arch, and extends to the abutment of the other, may be made of round iron, with a right and left handed screw in the centre, so as to expand the inner tire when the outer one has exceeded the diameter of the inner one, which is often the case after running a length of time; or they may be made as shewn in the drawing, of bar iron of suitable strength. Cast iron wheels may also be constructed on the same geometrical principle, with the strength of metal correctly proportioned.

A patent was granted, on the 4th March, 1842, to Mr. Edward Slaughter, of Bristol, "for improvements in the construction of iron wheels for railway and other carriages." Fig. 64 represents a wheel constructed on this plan, and consists of eight spokes produced with a dovetail projection on the outer side, and bent round a cast iron block, of any suitable form, and of such dimen-

sions that they may collectively serve as an inner framing to the wheel; the outer ring of wrought iron is furnished on its inner circumference with a dovetail recess, corresponding with the projecting dovetail of the spoke. When the outer ring has been welded together, the space where the weld was taken is dressed out on the face side, of sufficient width to receive the circular end of one of the spokes. The ring is then made hot, to expand the dovetail recess, and the eight spokes are slipped into it, so as to complete the frame of the wheel. The nave is then cast round the spoke ends, and the slot through which the spokes are introduced into the recess of the outer ring is filled up with a piece of metal, secured with two bolts, as clearly seen in the drawing.

Mr. Henry Smith, of Liverpool, obtained a patent on the 10th March, 1842, for "improvements in the construction of wheels and breaks for carriages." The invention relates to a mode of making railway wheels by combining cast-iron centres, wood felloes, and wrought-iron or steel tires, in such a manner that the wooden felloes are caused to be forced out and separated by means of wedges. Fig. 65 represents a wheel constructed according to Mr. Smith's patent; the centre part is of cast-iron, and should be made in one casting, the wood felloes are made in several parts, and the tire is of steel or wrought-iron; these parts are held together by bolts; angular pieces are placed between each pair of the parts of the wood felloes, and it is by forcing these angular pieces outwards from the centre of the wheel that the tire is, at all times, securely held, and the parts of the wheel retained together. The angular pieces are forced outwards by means of screws and wedging blocks, as seen in the detached drawing.

Mr. Henry Robinson Palmer, of Westminster, obtained a patent on the 26th April, 1842, for "his invention of an improvement or improvements in the construction of roofs and other parts of buildings; and also for the application of corrugated plates or sheets of metal to certain purposes, for which such sheets or plates have not heretofore been used." Fig. 66 represents a rail-

way wheel, having a corrugated plate in place of the usual spokes or arms. The rims and nave may be cast on to the previously prepared plate, and a tire may be added thereto in the usual way.

On the 28th of April, 1842, Mr. William Losh, of Newcastle-on-Tyne, obtained another patent for "improvements in the construction of wheels for carriages and locomotive engines, intended to be employed on railways." The invention consists in certain modes of securing the iron tire of wheels upon the ring or felloe, produced by the prolongation of the bars of iron employed to make the spokes. Fig. 67 represents a wheel with the bends or angles of the compound arm constituting the ring or felloe, not in contact, but left a distance of an inch asunder. Within this space I introduce two blocks of iron, properly shaped to fit the angles of the spokes, and having a groove in each of their flat sides, to receive a suitable key. When the tire is placed on the felloe, with or without the intervention of wood, felt, rope, or such like flexible or yielding material, and the blocks being properly applied between each pair of compound arms, iron keys are introduced, which, being driven between the blocks, divide them, thereby increasing the diameter of the felloes and tightening up the tire, which is afterwards secured by screws or rivets. Fig. 68 is another modification of this patent, in which the felloe or ring is composed of continuations of the bars forming the spokes; in fastening the tire upon this description of wheel, keys are introduced between the ends of each bent bar, forming parts of the felloe, where they rest upon the adjacent ones all round the wheel, which being sufficiently driven, enlarge the circumference of the felloe, so as to fix the tire, after which it is kept in its place by screws or rivets as before. Fig. 69 represents a wheel having a cast iron tire and curved malleable iron spokes. The tire is cast with bosses corresponding to the number of spokes, each spoke consisting of two iron bars, cast into the nave. The above bosses have each a dovetailed space to receive the spokes of the wheel, which being placed within the tire, and fitting

somewhat tightly, are divided by wedges, and forced asunder against the sides of the space within each boss, by which the tire is firmly secured. Fig. 70 represents a wheel, having what Mr. Losh calls compound spokes and felloes, the number of pieces of which it is composed may be varied, but Mr. Losh prefers four separate sets of spokes, all of which are secured into the nave by casting as usual; the outer tire may be secured by shrinking or by wedging, as already fully described in this specification. Instead of laying the several portions of each compound spoke together, so as to be exactly above each other when placed horizontally, the joints are allowed to intersect each other, as seen in the drawing.

Mr. Thomas Banks, of Manchester, obtained a patent of the 13th June, 1842, for "improvements in the construction of wheels and tires of wheels, to be employed on railways." This invention relates to a peculiar method of constructing the nave or boss of such wheels, for the purpose of securely fastening the wrought-iron arms or spokes in the nave, and to an improved method of forming the tire by inserting a hoop, bar, or segments of steel, iron, or hard metal in a groove formed entirely around the outer rim of railway wheels. Fig. 71, represents a wheel constructed according to Mr. Banks's patent; the wrought-iron spokes may be formed by any of the methods now in use, and securely attached to a wrought-iron ring, the nave is then formed by casting or running melted metal all round the ring and inner ends of the spokes, as shewn in the drawing. The improvement in the construction of the tire consists in introducing a hoop or segments of steel into a dovetail groove turned in the tire, the hoop or segments of steel must be heated and bent into the shape shewn by dotted lines above the section, before it can be put into the groove, it is then spread laterally so as to fill or become tight in the groove, by hammering or other pressure. Steel or other hard metal may also be applied in like manner to the working surface of the flange of the wheel.

Fig. 72, represents a wheel for railway carriages to which an apparatus is applied forming the subject of a patent granted to Mr. F. Lipscombe, of London. The title of whose patent was "for an hydrostatic engine, parts whereof are applicable as improvements to other engines, and other purposes, and also improvements in railway carriages." Dated 16th Aug., 1843. The apparatus above referred to is to obviate the intense vibration of railway wheels and axles, which is generally understood to cause rapid deterioration as regards their strength, and consists of two plates of zinc, placed on each side of the wheel for the purpose of retaining sawdust in contact with part of the rim and spokes; each plate has two wooden rings of unequal size permanently fixed to it, the external diameter of the smaller ring and the internal diameter of the larger ring are shewn by dotted circles. The combined depth of the corresponding rings is equal in width to the tire, these rings meet and are screwed together; certain parts of the rings being cut away to let in the spokes. The ends of the spokes are left exposed for the purpose of noticing any defect which may take place in those parts. This apparatus may be applied with slight modifications to all existing metal wheels.

Mr. Jonathan Saunders, of Birmingham, obtained a patent on the 5th Oct. 1843, for "improvements in the manufacture of tires of railway and other wheels, and in the manufacture of railway and other axles." This invention relates to a mode of manufacturing tires by so piling steel with iron that the steel may be at those parts of the surfaces most liable to wear when the piles of steel and iron are rolled into bars for making tires. Fig. 74, represents a section of a pile of iron and steel, which when rolled will produce a railway-tire similar to the section seen at Fig. 73. The position of the iron and steel in the pile may be varied as seen in section, Fig. 75, so as to produce a tire of the section, Fig. 76; by this process the steel will be incorporated amongst the iron, and for the most part come to the wearing surface of the tire; and the whole will be so combined that there

will be no probability of the steel and iron separating when in use.

On the 18th Dec. 1843, a patent was granted to Mr. Samuel Parlby, of Rutland Gate, Knightsbridge, for "certain improvements in the construction of wheels for carriages." This improved wheel is shewn in Fig. 77, and is constructed of a cast iron centre nave, put together in two pieces, the spokes are of wood, and are held into the nave by the bolts which connect the two parts of the nave together. The circumference of the wheel is formed by inserting segments of hard wood between the outer ends of the spokes, with the grain of the wood radiating from the centre of the wheel, and bolting upon these segments and spokes two wrought-iron rings, upon which a tire may be shrunk in the ordinary way; or one of the side rings may be made large enough to answer the purpose of a flange, and the wooden segments may bear upon the rail. Where wheels of great strength are required, as for locomotive engines, &c., two sets of spokes, of the kind above described, may be applied to each wheel.

A patent was granted to Mr. Samuel Atkinson, of London, for "improvement in the construction of wheels for carriages," dated the 4th of March, 1844. The patentee claims the method of constructing wheels having iron or other metal tube spokes, filled with wood, and combined with wood felloes and wood naves; there is no drawing attached to the specification to show the application of this invention to railway wheels.

Mr. André Drouet de Charlieu obtained a patent on the 20th March, 1844, for "improvements in rails for railways, and in wheels for locomotive carriages." This invention consists of a mode of manufacturing rails for railways, by applying to the sides of the rail an angular flange, in order to prevent the wheels of the carriage from running off the rail; the improvement in the wheels consists in dispensing with the flange now applied to the

wheels of locomotive engines and carriages to prevent the wheels from coming off the rails.

Mr. John Bower Brown, of Sheffield, took out a patent for "improvements in combining cast-steel with iron, and in the construction of carriage springs." Dated the 10th Oct., 1844. The first part of this invention consists in a mode of combining cast-steel with iron when manufacturing tires for railway wheels. A block of iron is provided, of such weight as will, together with the steel, make the size of bar required for the tire of a railway wheel. The block is heated to nearly the point of fusion, and placed in a cast-iron mould, of a suitable size to contain the iron and the cast-steel to be combined therewith; melted steel being now poured in, the steel and iron combine into one mass, which is then drawn out into a bar, and afterwards passed between grooved rollers, in order to obtain the desired form of tire.

Mr. Ernest Edge, of Manchester, obtained a patent on the 20th November, 1845, for "improvements applicable to the wheels and axles of engines, tenders, carriages, and waggons to be used upon railways." These improvements are intended to be adopted only in such cases where the wheels are mounted upon revolving axles, and are designed to facilitate the transit of carriages over curves, or other deviations upon the line of railway. In ordinary locomotive engines, tenders, carriages, or waggons, used on railways, the wheels are both "staked," keyed, or fastened upon their respective axles, and, consequently, both wheels revolve with the axles whilst running, and as is well known, in the event of passing over curves in the line, their action is not uniform, but subject to considerable friction and abrasion, or "twist," against one side of the rails. This invention consists in so constructing wheels and axles as to obviate this imperfection. The improvement is effected by "staking," keying, or fixing only one wheel upon the revolving axis, instead of both, and leaving the other wheel loose upon its axis, and at liberty to turn, slip, or even remain for a time quiescent, when occasion may require.

A patent was granted, on the 6th January, 1846, to Mr. Conrad Haverkam Greenhow, of North Shields, for "improvements in the construction of railways and railway carriages." The invention consists in the adaptation of peculiar concave flanged wheels, as seen in Fig. 78, with diagonal arms or spokes, to convex or cylindrical rails, shewing thereby the great importance of combining rails with wheels having running surfaces formed and fitted to each other.

Mr. Joseph Romauld Bozek, of London, obtained a patent, on the 6th January, 1846, for "improvements in the construction and application of railway carriage wheels." The following is Mr. Bozek's specification: "In the construction and application of railway wheels, as heretofore practised, it has been usual so to construct and apply them, that the single flange on each wheel shall come on the inside of the rails of a railway; and which construction and mode of application I have discovered to be objectionable, and that very important benefits will be derived by constructing and applying railway wheels so that the single flange on each wheel shall come outside of the rail on which it is moving. For this reason, in place of constructing the flange on the inner side, and then applying and keying the wheels on to their axles, so that the flanges come on the inside, I cause the flange of each wheel to be produced on the outer edge, and cause the wheels to be applied and keyed on to their axles in such a manner that the flanges will come on to the outside of the rails of a railway."

Mr. Thomas Melling, of Liverpool, obtained a patent on the 7th May, 1846, for "certain improvements in steam engines, marine, stationary and locomotive, and in machinery and apparatus connected therewith; parts of which are also applicable to regulating the flow of fluids generally." Most of the wheels shewn in this patent are constructed so as to tighten up the tire by expanding the body of the wheel. Fig. 79 represents a wheel, the body of which is cast of three segments, feathered and grooved into each other where they meet; these segments fit upon an ex-

panding cone formed of three parts, resting upon the axle and held in their places by a hoop made in two halves, over which a washer, coming flush with the journal is placed, as seen in the section. The outer tire is rolled with a fillet on its inner circumference, and a corresponding groove is made in the outer circumference of the segments forming the body of the wheel. In putting these wheels together it is evident that any stress that may be given to the cone above mentioned will be sustained by the hoop in two halves fitting into a groove in the axle, and in tightening up the cone, the groove in the segments take on to the fillet of the tire, and all the parts of the wheel become firmly united. Fig. 80 represents a wheel with wrought-iron arms cast in the boss, here also the arms form the inner rim of the wheel, but instead of the tire being rolled with a fillet, which fits into a groove in the periphery of the rim, the rim fits into a groove rolled in the tire, which permits the arms and the rim to be made of plain flat iron; the wheel is in other respects the same as that above described. Fig. 81 represents a wheel with wrought-iron arms cast in the boss, which is whole, the inner rim is of cast-iron, in segments, which are feathered and grooved where they meet each other. The outer extremities of these arms are screwed and have double nuts, by means of which the segments may be expanded. Mr. Melling considers this plan far inferior to that of expanding by a cone, as great care would be required to adjust the nuts so as to throw equal stress upon each segment. Fig. 82 represents a wheel, the rim of which is filled with wood, the segments forming the body are expanded by a cone provided with a flange; a similar flange is also made on the axle, and the cone is tightened up by bolts with counter-sunk heads passing through the flanges and the nave of the wheel: a great advantage is here derived from putting on the tire cold. Fig. 83 represents a wheel in which the tire is formed out of several ordinary sized iron bars, as seen in the section. To hold these bars together the wheel is cast in halves, with a flange on each side bearing upon the outside of the tire; these halves are coupled together by bolts and nuts. Should it be preferred to have the tire solid, these rings may be put together, heated in the furnace, and welded by a hammer. Tires con-

structed in this manner will be less expensive, and more certain of being sound in the welds than those in general use. Fig. 84 represents a wheel made wholly of wrought-iron, having two distinct bosses, and each boss is divided into four segments. The bosses are placed at a distance from each other on the axle. To each boss is welded an equal number of arms, placed with their edges in the running direction, so as to offer as little surface as possible to atmospheric resistance. To each arm is welded a corresponding segment of the rim, and these segments are separated from each other as seen in the drawing. As all the arms are placed in the centre of the rim, and half their number in the centre of each boss, it is obvious that they will stand in an angular direction with respect to each other, giving great lateral strength to the wheel. In putting the tire on, the diameter of the wheel is reduced, by forcing the bosses asunder; the bolts which connect the bosses are then tightened up, and the convex surface of the rim is forced into the concave surface of the tire, thereby securing all the parts of the wheel firmly together. The advantages derived from these various methods of constructing wheels are—First, that the wheel can be accommodated to the size of the tire, without that extreme nicety of workmanship which is at present required. Secondly, that there being a fillet or a groove in the under side of the tire corresponding to the surface of the inner rim, no rivets or bolts are required to keep it in its place, and, consequently, that no parts of it are rendered weaker than others. Thirdly, that as the tire is put on cold, its malleability is not injured by "slaking," as is very commonly the case with wheels as now put together. Fourthly, the facility in taking off or putting on the tires. Fifthly, that as the tires are put on cold, they can be casehardened, and all the advantages of steel tires obtained at far less cost; and, lastly, that the wheel being cast in separate pieces, they are less liable to break from unequal contraction in cooling.

Mr. Hugh Greaves, of Manchester, obtained a patent on the 22d of May, 1846, for "improvements in the construction of

railways, and the carriages to be used thereon." Fig. 85 represents a wheel constructed of malleable cast-iron and wood. The nave is cast with the requisite number of sockets, into which the wooden spokes are placed; the felloes are cast in segments, each with a tapering socket similar to those in the nave, and corresponding with the outer end of the spokes on which they are placed, (the sockets being somewhat smaller than the spokes) the whole is forced together with hydraulic pressure and the tire is shrunk on as usual; where the ends of the felloes meet, a half boss is cast on each, through the hole in the centre of which a bolt passes into the tire, thereby retaining each respective part in its proper position. Rings of malleable iron are also shrunk on the nave, as is the case in other railway wheels.

Mr. Robert Heath, of Manchester, obtained a patent on the 27th July, 1846, "for certain improvements in wheels to be used upon certain rail and other roads, which improvements are also applicable to mill-gearing and other similar purposes." This invention, which is applicable to carriage wheels, is represented at Fig. 86, and consists in the peculiar formation of the wheels, in connection with the particular relative proportions of the different parts of the same, whereby the contraction consequent upon the cooling of the metal in casting is caused (instead of weakening the wheel) to bind the whole together into one solid mass. The wheels are, in the first place, formed entirely of cast iron; and although any kind of metal may be used, the patentee prefers to make them of what is called "cold blast" metal, as being stronger and tougher than any other. The proportions which the patentee employs, and which he claims as his invention, are as follow:— "The outer rim and the boss of the wheel are three times the strength of the arms, or thereabouts. Hitherto cast-iron wheels have been liable to break, chiefly from want of a sufficiency of metal in the rim; because when the rim is not sufficiently strong, it cools first during the process of casting, and the contraction of the rim ceases, while the contraction of the arms and boss are still going on. By making the rim three times the

strength of the arms, or thereabouts, the contraction of the rim is greater, and lasts longer than that of the arms; and thus the arms and boss of the wheel are bound firmly together by the contraction of the rim. This perfect contraction of the whole causes the rim to assume a perfect circular form, so as to require no subsequent turning prior to use. The arms may be made either flat, round, or of any other shape; but they must retain the same sectional thickness at the rim as at the boss, and without any flanges or ribs, so that the arms shall not contract more, or sooner at one place than at another. It is also preferred to make the wheels with an uneven number of arms so as to assist the contraction of the rim; that is, having each arm opposite to the space between the two opposing arms. In making the driving wheels for locomotive engines, a ring of metal is cast about half way between the outer rim and the centre of the same, to prevent the thrust of the crank from breaking the arms; and this ring is made a little stronger than the arms, still preserving the above named proportions of the outer rim, arms, and boss."

Fig. 87 represents a wheel for the invention of which, a patent was granted to Mr. George W. Eddy, of Waterford, in America: the date of this patent is Nov. 3rd, 1846, and the title is for "an improvement in the manufacture of cast metal wheels for railway and various other carriages." The said improved wheel is composed of a cast metal rim and boss, united together by two cast metal plates, as seen in the section, the union of the same being effected by casting or founding the whole in one piece at one and the same time, and in a mould having an iron or metal chill properly adapted to it, so as suddenly to harden the periphery or tread of the wheel, during the operation of casting it. The improvement consists in the manner in which the front plate is formed, the same consisting in giving it an undulating or serpentine shape in any cross section of it, taken from the boss to the rim of the wheel, the inner plate is made convex; this form of wheel will not be injured by the contraction of the metal in cooling. Mr. Eddy proposes also to make both the plates of an un-

dulating shape in the section, instead of having one undulating and the other convex, as shewn in the drawing.

Mr. William Exall, of Reading, obtained a patent on the 3rd Nov., 1846, for "improvements in the construction of wheels, and in certain implements and tools employed therein, and in the mode of forming and manufacturing the tires of wheels, which mode is applicable to making metallic rings, bands, hoops, cylinders, and other similar articles." These improvements relating to wheels consist in certain apparatus for shaping the spokes and forming the tenons at their ends; secondly, in apparatus for cutting out and facing the felloe; thirdly, in tools for forming the mortise in the naves of wheels; fourthly, in an improved form for casting the naves of wheels; fifthly, in the mode of fixing the spokes and dowels of wheels in the naves and felloes, and, lastly, the improved mode of manufacturing the tires of wheels, which is applicable to making hoops, cylinders and other like articles, and consists in a method of forming them of malleable iron or other metal, without a weld-joint in the usual sense of the word.

A patent was granted to Mr. Henry Grafton, of London, on the 16th Jan., 1847, for "improvements in railway wheels and apparatus connected with railway carriages." The patentee shews the application of his peculiarly-made wheel as applied to carriages adapted for running along railways of two different gauges, without any change in the wheel itself; this is accomplished by making the felloes sufficiently wide to hold two of the ordinary flanged tires. Fig. 88 represents a wheel suitable for a common railway carriage: the nave is formed of cast-iron, and the plates which connect the nave to the tire are pressed into moulds, so as to produce corrugations, or radial indentations, upon them, as shewn in the drawing; the plates may be rivetted to the nave when the wheel is required to have a broad felloe, instead of being cast in it as shewn in the drawing. The principal feature in Mr. Grafton's patent is, the making of

wheels to run on railways of different gauges; the mode of constructing these wheels approaches very nearly to the inventions of Mr. Hick, in 1834, and of Mr. Palmer, in 1842.

Mr. Benjamin Tucker Stratton, of Bristol, took out a patent on the 6th of April, 1847, for "improvements in railways, and in wheels and other parts of carriages for railways, and common roads; partly applicable to the construction of ships or other vessels; and improvements in the machinery for manufacturing certain parts of the same." Fig. 89 represents a wheel made according to Mr. Stratton's specification: the improvement consists of forming the spokes of sectoral shaped loops of corrugated or hollow iron, of any form in section, or of flat, round, or oval rods of iron, or of angle or T iron. These spokes are placed with their flat sides towards each other, and have a plain radial spoke between each pair of sectoral spokes, and they are fastened together by bolting or rivetting; the naves are cast upon the inner ends of the spokes, after which the spaces at the junctions of the outer part of the spokes are filled with wood or other material, and a tire, put on in the usual way, completes the wheel. The patentee also proposes to obtain a nave of large diameter, by casting blocks of pumice-stone or bath-brick between the spokes, so as to have a large boss with the same weight of metal as a smaller one made entirely of metal.

Fig. 90 represents a wheel registered for Mr. Felix Abate, of London, on the 28th April, 1847. These wheels differ in construction and operation from any hitherto in use. The nave is not situated in a fixed manner in their centre as usual, but is moveable in all directions in the plane of the wheel. It is supported and surrounded by eight semi-circular steel springs, which at one end are fixed in it, in suitable enchasing, and at the other end, in the circumference of an inner circle, which occupies the middle part of the wheels; these springs entirely supersede the usual ones that are inserted between the body of the carriage and the axles. The above is the description of the wheel according to Mr. Abate.

Mr. Frederic Chaplin, of Bishop's Stortford, obtained a patent on the 29th of June, 1847, "for improvements in the wheels of railway carriages." The nature of this invention consists in attaching to the wheels of carriages, strips of leather, which will give to the driving-wheels of the locomotive engine a better power of biting on the rails, and when applied to the wheels of other railway carriages will cause them to run with less noise, and more smoothly. Fig. 91 represents a section of a railway tire, having a groove extending all round it, three-quarters of an inch deep and half an inch wide, placed as nearly as possible in the centre of the tread: this groove is tightly filled with strips of strong ox or buffalo hide, not otherwise prepared or dressed than merely dried, which are rivetted together in different lengths, so as to break the joints before they are hammered into the groove of the tire. To secure this band of leather, iron bolts are passed through the outer edge of the tire, and through the belt into the iron on the other side of it, at intervals of about two feet all round the wheel. The edges of the groove should be rounded off, so that the weight of the wheel may not act too strongly on the edge of the iron. The belt may also be fastened into the groove by means of a small key or bracket, shewn in Fig. 92, the segmental part of which is placed between the strips of leather forming the belt, and rivetted to them; the shank or leg of the key is then passed through a hole in the tire, at the bottom of the groove, and secured by a nut. Fig. 93 shews a section of a complete tire, constructed according to Mr. Chaplin's patent.

Mr. William Edward Newton, of London, obtained a patent on the 28th of June, 1847, for "certain improvements in manufacturing wheels," being a communication. This invention consists in a peculiar method of casting iron wheels for locomotive engines and railway-carriages, the particular object of which is to cool uniformly all parts of the casting at the same time, and thereby prevent fractures in the wheel from irregular shrinking. Fig. 94 represents a wheel, the whole of which is cast in a chill, thus cooling all the parts at the same time, without undue strain. The inventor remarks, in the specification of his patent, that it

has been found by experience sufficient to chill only one side of the wheel to ensure the uniform shrinking of the metal, he therefore proposes to construct the metal mould of the wheel of the requisite number of parts to chill the outer circumference of the tire, the hole through the nave and the back of the wheel, leaving the front of the wheel to be moulded in sand.

Fig. 95 represents a wheel constructed by R. Stephenson and Co. The spokes are formed of rolled T iron bent round a block, the ends being slightly bevelled inwards at the points, to give the ends of the spokes a better hold in the boss. Each spoke, or rather each pair of half-spokes is now laid on a plate, and the boss cast on in the usual manner. The tire is now shrunk on, and the vacant spaces at the parting of the spokes where they meet the inner side of the tire, are filled up with baked oak timber, which is secured by driving into it two small iron wedges. It will be seen that the projecting fin on the spoke-iron is not in the centre of the metal, this is to allow of the insertion, on the wider side, of a bolt for securing the rim portion of the spokes to the tire. The spokes are also bolted together in the centre of the space from the tire to the nave.

Fig. 96 represents a wheel made with wrought iron spokes and felloes, and a cast-iron nave. The wheels are particularly applicable to locomotive engines, owing to their durability. The spokes are welded to short segments forming part of the felloe, and then cast into the nave; the short segments are afterwards welded together, so as to form the entire felloe, which, after it has been turned in the lathe, is ready to receive the wrought-iron tire, which is shrunk on in the usual manner.

Fig. 97 represents a cast-iron wheel, constructed by Mr. J. G. Bodmer, of Manchester. It will be seen, on reference to the section, that the spokes are cast hollow, and the core of each spoke is enlarged near the centre of the wheel, so as to reduce the weight of the nave; the nave is so shaped that it projects over a part of

the axle-box, and prevents, in a great measure, the dirt and dust from getting to the axle-bearing. After the felloe of the cast-iron wheel has been turned true, one of Mr. Bodmer's patent rolled tires is put on it, and the whole plunged into cold water. These tires are manufactured by Mr. P. R. Jackson, at the Salford Rolling-mills, near Manchester, and are used on most of the railways in England; they are made of the usual tire-iron, bent into circles and welded into hoops, these hoops are put into a stove and heated almost to a white-heat, they are then put into the rolling-mill, which is constructed of two vertical shafts, each provided with a small roller, so shaped that when the rollers are in their proper positions, they leave a space between them equal to a section of the tire; these rollers can be separated so as to admit the tire between them, and they are brought nearer together during the process of rolling. The tires thus made are so true that they do not require to be turned in a lathe, and the surface is as hard as hardened steel owing to the scale being left on.

Fig. 98 represents a wheel, generally called the "Pimlico Wheel;" it is formed of a cast-iron nave, having mortises to receive the wooden spokes, the felloes are segments of wood let on to the spokes, each spoke having a separate felloe, which admits of the spoke being very stiff, and in putting the wheel together there is no need to strain the spokes, as is the case where one felloe is used to every two spokes. The felloes are put together with dowels between the joints, and are secured by a thin wrought-iron hoop, upon which the outer tire is shrunk in the usual way. These wheels were invented by Mr. Y. Parfray, resident engineer of the Pimlico works, and were first tried on the London and Birmingham line, 1843, since then about 5,000 of them have been made, for various railways in England and on the continent; they are made entirely by steam-power and machinery, and the cost of them is about the same as the best wrought-iron wheels; they are considered an improvement on the iron ones, inasmuch as they are lighter, easier, and make less noise. The Pimlico wheel is not protected by a patent, and has consequently been extensively imitated by other makers.

Fig. 99 represents a cast-iron wheel with a wrought-iron tire constructed by Mr. Richard Roberts, of Manchester, in 1833. The wheels are so carefully proportioned in their several parts that they are not injured by contraction in cooling. The outer tire is shrunk on after the felloe has been turned in the usual manner. These wheels have been in work for many years under engines, tenders and carriages, and have given perfect satisfaction.

Fig. 100 represents a wheel constructed by Messrs. Sharp, Roberts and Co., in 1840, for the Bristol and Exeter Railway Company. The arms or spokes are welded to the felloe, in the manner shewn in the section, that is to say, half the spokes are slanted in one direction and the other half are slanted in the opposite direction, thereby giving strength to resist any lateral pressure. The nave is cast around the ends of the spokes and the tire shrunk on in the usual manner.

Fig. 101 represents a wheel constructed by Messrs. Sharp, Brothers, and Co., in 1846, and very extensively used by them for the tenders of their locomotive engines; the wheels are made of cast-iron, and the outer circumference is turned to receive the wrought-iron tire which is shrunk on in the usual manner. It will be seen, on reference to the section, that the back of the nave is provided with a rim or flange opposite to the web of the spokes, so as to give additional stiffness to the spokes, and to strengthen the nave against splitting during the operation of keying it on to the axle; the flange of the tire is placed on the opposite side of the wheel to the web of the spokes, thereby rendering the wheel more able to resist lateral strain. Cast-iron wheels of similar construction, of 4 ft. 6 in., and 5 ft. diameters are used by the above firm for all their heavy luggage engines.

The Author has endeavoured to give a correct abstract of each description of wheel mentioned, but, if he has unintentionally made any misrepresentations, it will give him great pleasure to rectify the same, in any future edition, on having the mistakes pointed out by the inventors. The Author would also be most happy to receive communications from any party who has constructed an improved railway-wheel, not mentioned in the list, as it is his intention to publish an appendix shortly, containing the most recent inventions, and those wheels that have been omitted in the present work.